

Mercury Availability and Methylmercury Generation Potential in SouthEast Connector Floodplain (Ref: Public Notice SPK-2010-01058, SEC, NV)

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During the March 12, 2014 tele- and video-conference to discuss Clean Water Act 404/401 Permit Applications for with the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), Nevada Division of Environmental Protection (NDEP) and U.S. Fish and Wildlife Service (USFWS), considerable discussion focused on the potential for sedimentation of the Washoe County Regional Transportation Commission (RTC) SouthEast Connector (SEC) Project floodplain along Steamboat Creek during out-of-bank events and potential for methylmercury (MeHg) generation.

CH2M HILL has prepared this Technical Memorandum (TM) to (1) summarize the potential for overbank conditions, (2) describe elemental mercury (Hg) and sediment loads to the floodplain based on available historic data and (3) present and discuss floodplain conditions during overbank events and their potential to generate MeHg.

BACKGROUND AND GEOCHEMICAL SETTING

In the late 1800s, mills near Washoe Lake, Nevada used elemental mercury (Hg) to amalgamate gold and silver from the ores of the Comstock deposit. A significant, albeit poorly quantified, amount of mercury was lost to the environment from the amalgamation process. Since that time, mercury has been distributed by normal sediment transport and flood events from Washoe Lake, down Steamboat Creek, and to the Truckee River. Steamboat Creek provides irrigation water to agricultural lands within the watershed and sediment borne mercury has been transported from the Steamboat Creek channel to irrigated pastures during past and ongoing flood irrigation. Testing of channel sediments and floodplain soils within the Steamboat Creek watershed contains elevated levels mercury. In addition to elemental mercury present in the soils and sediments, mercury is also present in the water column in the form of Total Suspended Sediments (TSS) and to a far lesser extent as dissolved Methylmercury (MeHg). Station #SB19 (STORET ID NV06-102-T-024; Steamboat Creek @ Cleanwater Way) provides the following grab/surface water quality results on October 15, 2008¹.

¹ <http://ndep.nv.gov/bwqp/sb19.html>

TABLE 1. STORET ID NV06-102-T-024 OCTOBER 15, 2008 GRAB/SURFACE WATER QUALITY RESULTS

Temp (°C)	DO (mg/L)	pH	SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)	CO3 (mg/L)	Total Hg (ug/L)
11.3	11.6	8.46	93	843	26	12	<0.2

A 2004 study performed by Stamenkovic, J., et.al.² was to determine concentrations of total mercury and methylmercury in surface sediments and characterize their spatial distribution in the Steamboat Creek watershed. Total Hg concentrations measured in channel and bank sediments did not decrease downstream, indicating that Hg is distributed along the creek's entire length. Total Hg in sediments ranged from 0.01 to 21.43 ug/g and was one to two orders of magnitude higher than those in pristine systems. At 14 of 17 sites, MeHg concentrations in streambank sediments were higher than the concentrations in the channel, suggesting that low banks with wet sediments might be important sites of mercury methylation process to occur in this system. Both pond/wetland and channel sites exhibited high potential for mercury methylation. In this study, methylation potential was positively correlated with sulfate reduction rates, and decreased as a function of reduced sulfur and MeHg concentration in the sediments. Potential demethylation rates appeared not to be influenced by MeHg concentration, sulfur chemistry, dissolved organic carbon (DOC), sediment grain size or other parameters, and showed little variation across the sample sites.

In an Applied and Environmental Microbiology article³, MeHg potential in Clear Lake, California was positively correlated with sediment percent carbon, which highlighted the importance of heterotrophic biological activity for driving mercury methylation in the sediments. This study suggested that eutrophication may increase mercury methylation, either by altering sediment microbial communities or by increasing sediment organic carbon loading. Sulfate-rich waters from mining impacted water inputs to freshwater bodies appear to be a major source of sulfur and could contribute to increased production of MeHg, but that the lack of a strong relationship between sulfate reduction and mercury methylation also suggests that other bacterial groups which methylate mercury are potentially important.

These studies amongst others referenced in the Technical Memorandums included as appendices to the SEC 404 permit application demonstrate the multi-parameter influences of the Hg methylation process. And the great variability observed in the field as a function of biogeochemical conditions, availability of electron donors and receptors, anaerobic metabolic process, and associated hydrological regimes that influence these conditions.

SEC FLOODPLAIN LOADING

The above studies suggest that a variety of factors influence the Hg loading and subsequent occurrence for and rate of methylation. To assess Hg loading further, and relying upon the SEC hydraulic design whereby >16 cubic feet per second (cfs) of Steamboat Creek water would overbank the creek's west bank along the North and South Butler Ranch property, the mean of Steamboat Creek's daily mean discharge values (in cfs) from the USGS Gage at Short Lane (Alexander Lake Road) were tabulated, as shown on Figure 1 (Attachment A). This 14 year data set, which included total flows from the 1997 and 2004 flood events, identify between 0 and 743 acre feet (af) of overbank water that could be deposited monthly onto the floodplain (Figure 2, Attachment A). Using the total Hg and total suspended sediment (TSS) values presented in Table 1, and the mean of the daily mean values presented in Attachment A,

² Stamenkovic, J., Gustin, M.S., Marvin-DiPasquale, M. C., Thomas, B.A., Agee, J.L. 2004 Distribution of Total and Methyl Mercury in Sediments along Steamboat Creek, the Science of the Total Environment, in press. (NAES # 52031394)

³ Macalady, J.L., Mack, E.E., Nelson, D.C., Scow, K.M. Sediment Microbial Community Structure and Mercury Methylation in Mercury-Polluted Clear Lake, California

the total maximum mass of Hg that could be deposited onto the floodplain credit basins is 0.43 kilograms (kg) per year. This estimate assumes that all (1) suspended sediment contains an average of 0.2 ug/L total mercury and (2) sediment is deposited onto the floodplain credit basins. The project scientists recognize that this is a very conservative estimate and that it is unlikely, if not impossible, that all of the TSS associated Hg settled out on the flood plain. For demonstration purposes we have made this assumption to provide the worst case scenario based on available data.

METHYLATION POTENTIAL

As indicated in the permit application and elsewhere, the process of methylation and demethylation are influenced by the presence of aqueous anaerobic environment. The floodplain topography and planting palette have been developed to positively drain, which limits ponding where possible. This design reflects a seasonal out-of-bank flow regime that allows for the inundation of the floodplain for several weeks; generally early in the season when temperatures are low, which minimizes the methylation rate as a function of biological metabolism. Cooler water temperatures also reduce oxygen consumption by algae and bacteria that form anaerobic conditions in the near-surface soil, thereby delaying the formation of methylation conditions. Overbank flooding occurring early in the season when water temperatures are cooler also delays the onset of anaerobic conditions due to the source water from Steamboat Creek containing a higher concentration of dissolved oxygen than during high water temperatures later in the summer.

The overall design is focused on reducing channel velocities and scour and addressing new Hg containing sediments entering the system since virtually all of the historic sediments within the project alignment will be excavated and removed from potential environmental exposure or transport to wetland areas. The terrain has been engineered to limit the depth of the ponded waters in the floodplain to a depth that will infiltrate within a few days and/or drain to Steamboat Creek leaving an unsaturated surface layer that will oxidize as it dries, further reducing the methylation potential.

CONCLUSION

The SEC project proposes to remove an estimated 10,000 kg of total Hg from the Steamboat Creek system and permanently isolate these materials beneath the roadway. Unstable, incised Steamboat Creek bank conditions along the project's alignment and elsewhere are known to source total Hg and sediment to the Truckee River, a condition that will continue unless efforts are made to stabilize the system. Concerns expressed related to the SEC floodplain design have been focused on the potential to generate methylmercury resulting from future overbank flood conditions depositing sediment borne Hg from Steamboat Creek onto the floodplain, a condition that is already occurring and that is certain to continue throughout system. The floodplain design attempts to minimize this potential based on what is noted above and the project's environmental enhancements will substantially improve the stability of the Steamboat Creek system along the affected portion of its reach.

Considering the available overbank hydrology containing mercury (Appendix A Figures 1-3) an estimate of 0.43kg/yr of Hg could be deposited on the floodplain and potentially be available to methylation process. Therefore after 100 years it can be assumed that approximately 43 kg of mercury could be deposited on the floodplain. This is a relatively small risk of future potential sources for methylmercury considering that the proposed project will permanently remove approximately 10,000 kg of Hg from future exposure to the natural and human environment.

Failure to implement the floodplain restoration associated with the SEC will result in the exposure of the existing Hg to the steamboat Creek and Truckee river, allow existing excessive sediment transport of Steamboat Creek sediments to enter the Truckee River, where the recent public restoration projects of

Lockwood, Mustang, McCarran Ranch, and the 102 Ranch have intentionally created habitats that will promote methylation associated with overbank flooding and creation of ponding within the floodplain.

Therefore the best action that can be taken to limit the existing and future methylation potential and associated exposure of the system biota to MeHg is to stabilize the Steamboat Creek system through isolation of the existing Hg as proposed, reduce the energy of the system through reconnection of the channel to the floodplain, and focus future regulator and funding efforts on addressing the source areas for Hg within the Steamboat Creek watershed.

Attachment A – USGS Gage @ Short Lane Mean of Daily Mean Discharge Values (Figure 1), Overbank Flow Rates (Figure 2), and Overbank Volume & Estimated Floodplain Credit Basin Hg Loading (Figure 3)

Figure 1

USGS Gage @ Short Lane - Discharge, cubic feet per second, Mean of daily mean values for each day for 13 - 14 years of record in, ft ³ /s (Calculation Period 1981 10-01 -> 2013-09-30)												
Day of month	Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	43	12	15	10	17	25	24	9.1	4.7	5.5	7.4	12
2	58	12	16	10	17	25	23	9.1	4.5	6.1	7.9	25
3	24	12	19	11	20	26	22	9.3	4.5	6.6	8	17
4	26	12	14	11	21	28	21	8	4.4	7.1	8.3	11
5	24	11	13	11	20	32	20	7.6	4.2	10	8.1	11
6	15	12	12	10	21	43	20	7.7	4	10	8.1	9.9
7	14	12	13	10	20	35	19	7.9	4.3	8.3	8.1	11
8	13	12	12	9.7	21	32	18	7.6	4.7	7.9	9.3	11
9	13	12	12	9.4	21	33	18	6.9	4.8	7.7	10	10
10	14	11	12	8.9	20	33	17	6.2	4.9	7.9	9.4	9.6
11	14	12	12	9.3	19	31	16	5.4	5.2	7.5	9	9.6
12	13	12	11	16	18	29	15	4.8	5.7	6.9	8.4	9.7
13	14	12	11	14	18	28	14	4.9	5.8	6.9	8.2	9.4
14	12	12	12	14	18	26	14	4.8	5.9	14	8.3	9.7
15	12	12	12	13	19	26	15	4.8	6.3	6.8	8.5	11
16	12	12	14	13	19	26	14	4.8	9.1	6.2	9	13
17	12	12	12	14	20	27	14	4.8	8.8	6	9.3	12
18	12	12	11	14	25	30	13	4.6	8.3	6.6	8.6	13
19	12	12	11	15	30	31	12	4.4	8.4	6.5	8.3	34
20	12	11	11	13	29	30	11	4.5	8.5	7.9	8.1	21
21	17	12	11	14	27	29	11	4.5	8.3	7.2	8	15
22	13	13	12	14	26	29	11	4.4	8.6	7.1	7.9	20
23	14	13	12	15	27	29	11	4.7	8.2	7.1	7.7	15
24	13	14	12	14	25	27	11	4.5	9.1	8.4	8.5	14
25	13	14	13	14	25	25	11	4.4	9.2	18	8.6	12
26	13	14	12	15	23	24	10	4.5	10	9.4	8.2	12
27	13	20	11	15	24	22	9.8	4.2	9.9	8.4	8.4	12
28	13	38	12	15	24	23	9.7	4.3	9.1	8	8.6	12
29	13	11	11	15	24	25	8.7	4.5	9.8	7.6	8.7	16
30	12		10	16	24	26	8.9	4.8	9.8	7.5	11	14
31	12		10		26		8.6	4.6		7.4		123

Notes:
 .2 ug/l = .0002 g/m³; 26 mg/l = 26 g/m³.
 * Short Lane Gage Station is mid way between South and North Butler Ranch
 * Overbank estimate for north and South Butler Ranch; Channel Capacity of 16 CFS
 * All flows greater than 16cfs are available to floodplain
 * Data included total flows of the 1997 and 2004 flood events (not flows in late Dec and early Jan)
 * 1 cfs = 1.98 af/day
 * 1 af = 1233.48 m³
 = indicate elevated values due to 1997/2004 flood events

Calculate flow rate
available to floodplain
using a channel
capacity of 16 cfs

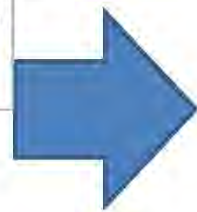


Figure 2

USGS Gage @ Short Lane - Discharge, cubic feet per second, Overbank estimate for north and South Butler Ranch; Channel Capacity of 16 CFS (All flows greater than 16cfs are available to floodplain)													
Day of month	Mean of daily mean values for each day for 13 - 14 years of record in, ft3/s (Calculation Period 1981-10-01 ->												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	27	0	0	0	1	9	8	0	0	0	0	0	0
2	42	0	0	0	1	9	7	0	0	0	0	0	9
3	8	0	3	0	4	10	6	0	0	0	0	0	1
4	10	0	0	0	5	12	5	0	0	0	0	0	0
5	8	0	0	0	4	16	4	0	0	0	0	0	0
6	0	0	0	0	5	27	4	0	0	0	0	0	0
7	0	0	0	0	4	19	3	0	0	0	0	0	0
8	0	0	0	0	5	16	2	0	0	0	0	0	0
9	0	0	0	0	5	17	2	0	0	0	0	0	0
10	0	0	0	0	4	17	1	0	0	0	0	0	0
11	0	0	0	0	3	15	0	0	0	0	0	0	0
12	0	0	0	0	2	13	0	0	0	0	0	0	0
13	0	0	0	0	2	12	0	0	0	0	0	0	0
14	0	0	0	0	2	10	0	0	0	0	0	0	0
15	0	0	0	0	3	10	0	0	0	0	0	0	0
16	0	0	0	0	3	10	0	0	0	0	0	0	0
17	0	0	0	0	4	11	0	0	0	0	0	0	0
18	0	0	0	0	9	14	0	0	0	0	0	0	0
19	0	0	0	0	14	15	0	0	0	0	0	0	18
20	0	0	0	0	13	14	0	0	0	0	0	0	5
21	1	0	0	0	11	13	0	0	0	0	0	0	0
22	0	0	0	0	10	13	0	0	0	0	0	0	4
23	0	0	0	0	11	13	0	0	0	0	0	0	0
24	0	0	0	0	9	11	0	0	0	0	0	0	0
25	0	0	0	0	9	9	0	0	0	2	0	0	0
26	0	0	0	0	7	8	0	0	0	0	0	0	0
27	0	4	0	0	8	6	0	0	0	0	0	0	0
28	0	22	0	0	8	7	0	0	0	0	0	0	0
29	0	0	0	0	8	9	0	0	0	0	0	0	0
30	0	0	0	0	8	10	0	0	0	0	0	0	0
31	0	0	0	0	10	0	0	0	0	0	0	0	107




Convert from overbank flow rate to overbank volume per day

Figure 3

USGS Gage @ Short Lane - Overbank Volume (acre feet/day)													
Overbank estimate for north and South Butler Ranch; Channel Capacity of 16 CFS													
Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	53	0	0	0	2	18	16	0	0	0	0	0	
2	83	0	0	0	2	18	14	0	0	0	0	18	
3	16	0	6	0	8	20	12	0	0	0	0	2	
4	20	0	0	0	10	24	10	0	0	0	0	0	
5	16	0	0	0	8	32	8	0	0	0	0	0	
6	0	0	0	0	10	53	8	0	0	0	0	0	
7	0	0	0	0	8	38	6	0	0	0	0	0	
8	0	0	0	0	10	32	4	0	0	0	0	0	
9	0	0	0	0	10	34	4	0	0	0	0	0	
10	0	0	0	0	8	34	2	0	0	0	0	0	
11	0	0	0	0	6	30	0	0	0	0	0	0	
12	0	0	0	0	4	26	0	0	0	0	0	0	
13	0	0	0	0	4	24	0	0	0	0	0	0	
14	0	0	0	0	4	20	0	0	0	0	0	0	
15	0	0	0	0	6	20	0	0	0	0	0	0	
16	0	0	0	0	6	20	0	0	0	0	0	0	
17	0	0	0	0	8	22	0	0	0	0	0	0	
18	0	0	0	0	18	28	0	0	0	0	0	0	
19	0	0	0	0	28	30	0	0	0	0	0	36	
20	0	0	0	0	26	28	0	0	0	0	0	10	
21	2	0	0	0	22	26	0	0	0	0	0	0	
22	0	0	0	0	20	26	0	0	0	0	0	8	
23	0	0	0	0	22	26	0	0	0	0	0	0	
24	0	0	0	0	18	22	0	0	0	0	0	0	
25	0	0	0	0	18	18	0	0	0	4	0	0	
26	0	0	0	0	14	16	0	0	0	0	0	0	
27	0	8	0	0	16	12	0	0	0	0	0	0	
28	0	44	0	0	16	14	0	0	0	0	0	0	
29	0	0	0	0	16	18	0	0	0	0	0	0	
30	0	0	0	0	16	20	0	0	0	0	0	0	
31	0	0	0	0	20	0	0	0	0	0	0	212	

Total Monthly Volume (AF) of Overbank Water =	190	51	6	0	380	743	83	0	0	4	0	285	1,742
Total Monthly Volume (m ³) of Overbank Water =	234,460	63,500	7,327	-	468,920	915,859	102,576	-	-	4,885	-	351,690	2,149,216



Average [TSS] = 26 g/m³
 Average [Hg] = 0.2 ug/l = .0002 g/m³; 26 mg/l = 26 g/m³.
 Estimated Total TSS-Hg (kg/yr) = 0.4298 kg/yr

[Hg] TSS (ug/L) =	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
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Total Monthly Mass of Hg available to floodplain (kg) =	0.047	0.013	0.001	-	0.094	0.183	0.021	-	-	0.001	-	0.070	0.4298 kg/yr
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